

Radiation Diagnostics for the TWP-ICE CRM Intercomparison Study

Ann Fridlind and Andrew Ackerman • NASA GISS

Jon Petch and Paul Field • UK MetOffice

Greg McFarquhar • University of Illinois

Shaocheng Xie • LLNL

Minghua Zhang • Stony Brook University

Peter May • Center for Australian Weather and Climate Research

Christopher Williams • NOAA Earth System Research Laboratory

Guosheng Liu • Florida State University

Sally McFarlane, Jim Mather and Chuck Long • PNNL

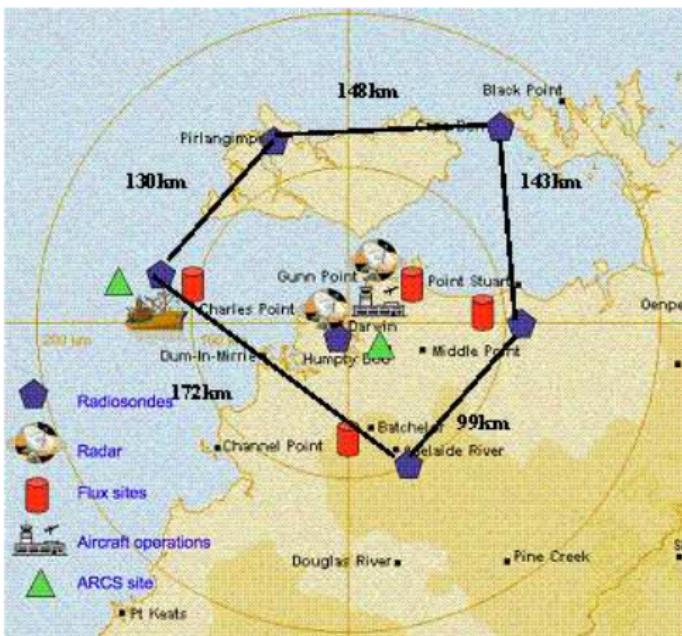
Pat Minnis • NASA Langley Research Center

Robert McCoy • Sandia National Laboratories

Courtney Schumacher • Texas A&M University

2006 Tropical Warm Pool - International Cloud Experiment (TWP-ICE)

Experiment domain

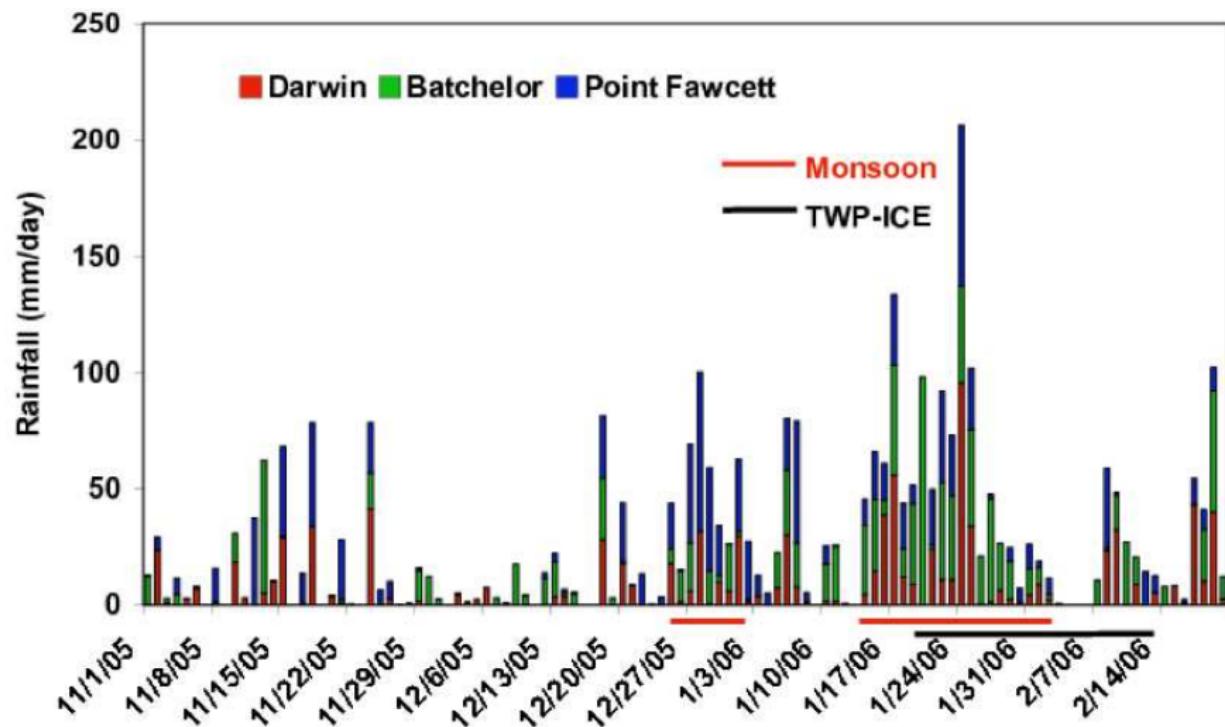


Source: *Shaocheng Xie, LLNL*

Experiment goals

- make detailed measurements of cirrus microphysics and their relationship to storm structure and intensity
 - characterize and document evolution
 - microphysical properties
 - large-scale environment
 - convective boundary layer
 - dynamical and **radiative impacts**
 - verify remote-sensing data
 - provide data for forcing and **evaluating models**

Conditions encountered



Source: *Lori Chappel, Australian BOM*

Model intercomparison studies

- interlocking studies - Jon Petch
 - Global Energy and Water cycle EXperiment (GEWEX) Cloud System Study (GCSS) - Precipitating Cloud Systems
 - Stratospheric Processes And their Role in Climate (SPARC)
 - cloud-resolving models (CRMs) - Ann Fridlind
 - 16 days
 - single-column models (SCMs) - Christian Jakob/Laura Davies
 - 26 days
 - limited-area models (LAMs) - Maria Russo
 - several days

CRM study participants

- Ann Fridlind, NASA GISS
- Jon Petch, UK MetOffice
- Wojtek Grabowski, NCAR
- Yi Wang, PNNL
- Xiaohong Liu, PNNL
- Charles Seman, GFDL
- Annica Ekman, Stockholm University
- Axel Seifert, German Weather Service
- Virginie Marécal, University of Orléans/CNRS
- Jean-Pierre Chaboureau, University of Toulouse/CNRS

CRM study goals

- evaluate models
 - simulations and data agree?
 - data sufficient to evaluate models?
 - additional data needed?
 - methodology sufficient?
- quantify convective transport to the tropopause
 - CRM predictions consistent with measurements and theory?
 - temporal and spatial characteristics of vertical mass transport?
 - influence on water vapor near the tropopause?
 - primary uncertainties in simulations and data?

Data constraints on model performance

Physical Variable

Precipitation rate

Liquid water profile

Liquid water path

Ice water profile

Ice water path

Total condensate content

Total condensate path

Water vapor

Cloud base height

Cloud top height

Cloud fraction

Radar reflectivity

Doppler velocity

Data Set (PI)

C-pol (May), disdrometer and buckets (Williams)

disdrometer, TCPRHP (McFarlane/Mather)

MWR (Turner), TCPRHP

TCPRHP, 3D-Ice (Liu)

VISSST (Minnis), TCPRHP, 3D-Ice

CSI (McFarquhar)

MODIS

sondes (Jakob/Hume), in situ (Whiteway, Hacker)

ARSCL, VISSST (Minnis)

ARSCL, VISSST

TSI (Morris), SFA (Long), MODIS

C-pol, S-band (Williams), disdrometer

S-band, disdrometer

Data constraints on model performance

Physical Variable

Particle number

Particle area

Particle size

Cloud optical depth

SFC broadband flux

TOA broadband flux

Column absorption

Broadband flux profile

Broadband heating rate profile

Latent heating rate profile

Surface SH and LH fluxes

Data Set (PI)

CIP (McFarquhar)

CIP (McFarquhar)

C-pol, disdrometer, TCPRHP, VISST, MODIS

TCPRHP, VISST, MODIS

TCPRHP, SKYRAD/GNDRAD

TCPRHP, VISST

TCPRHP

aircraft (McCoy), TCPRHP

TCPRHP

C-pol (Schumacher)

eddy-correlation (Beringer)

<http://www.giss.nasa.gov/~fridlind/twp-ice/data>

GISS simulations

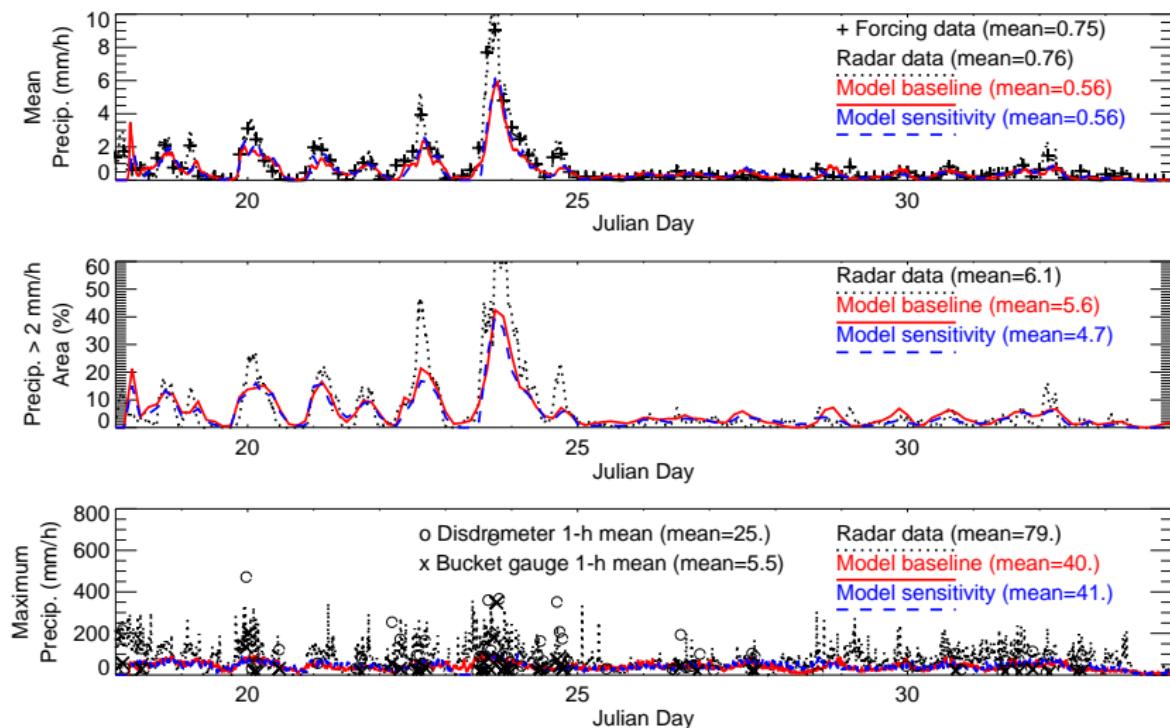
- general

- horizontal domain size = 176 x 176 km
- periodic boundary conditions (idealized marine)
- fixed SST = 29°C
- interactive surface fluxes
- large-scale forcings from variational analysis
- baseline and sensitivity test
 - nudge Θ , water vapor at $Z > 13\text{--}15$ km, $\tau = 6$ h
 - nudge at $Z > 0.5\text{--}1$ km, $\tau = 6$ h

- example

- vertical domain size = 24 km
- horizontal grid = 1 km
- vertical grid = 100–250 m
- bulk microphysics (Grabowski, 1999)
= cloud liquid, rain, fluffy ice, dense ice

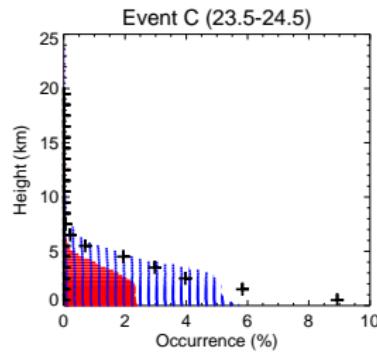
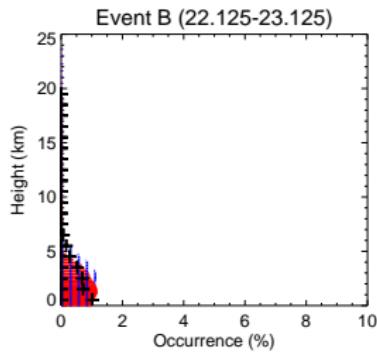
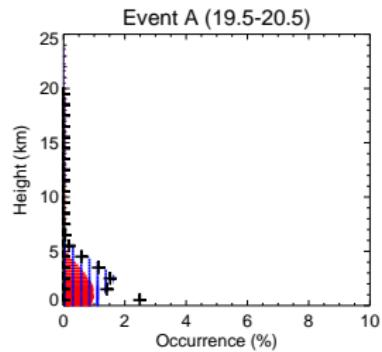
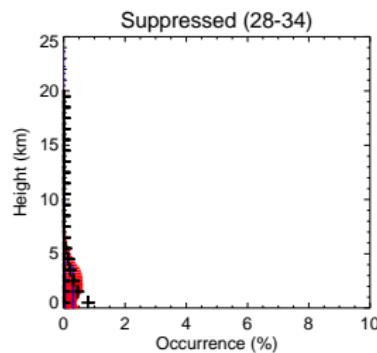
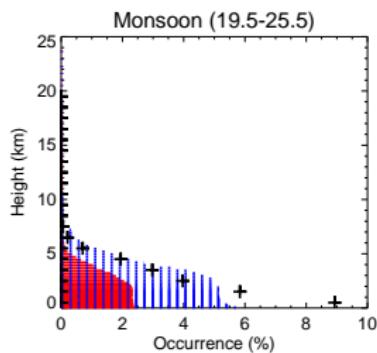
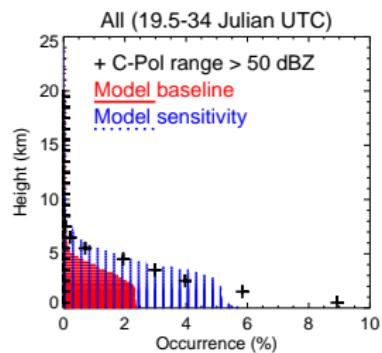
Precipitation rate



Data: Shaocheng Xie, Peter May, Christopher Williams

CRM Case Study Results

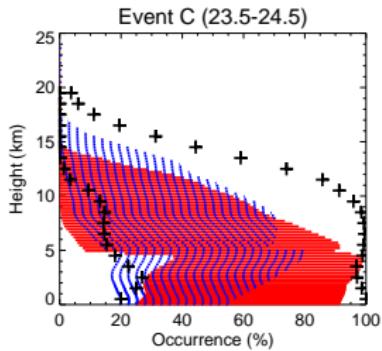
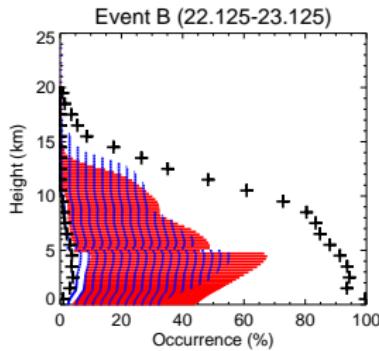
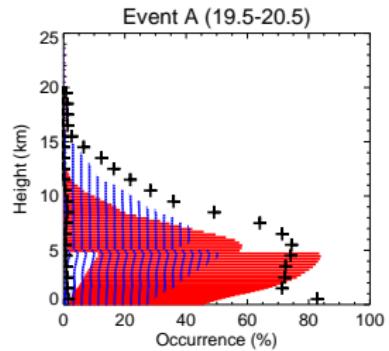
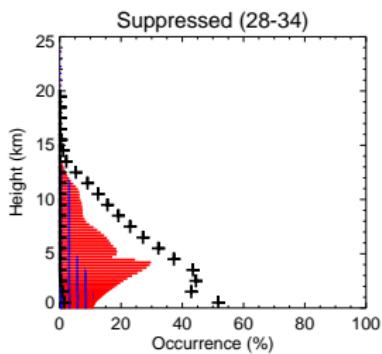
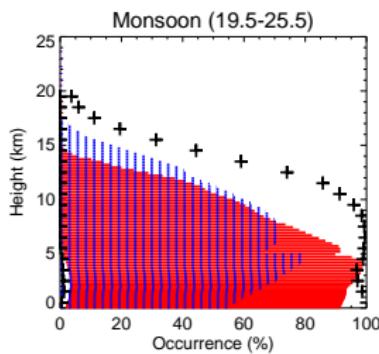
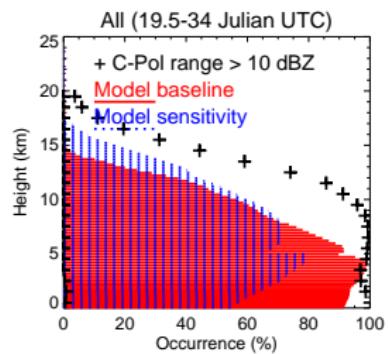
Radar reflectivity > 50 dBZ



Data: *Peter May*

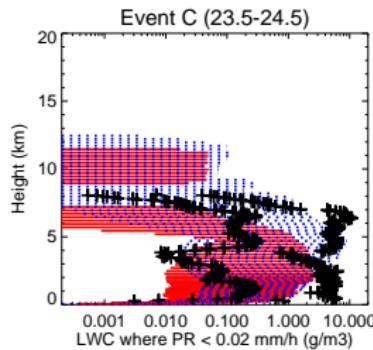
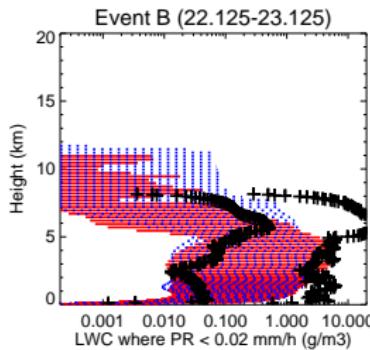
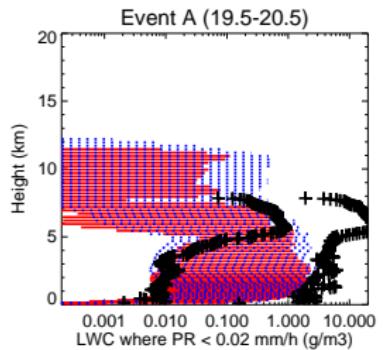
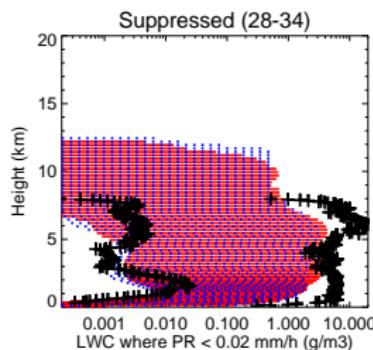
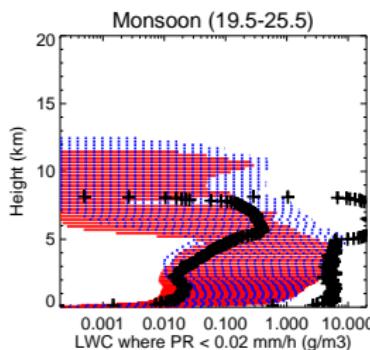
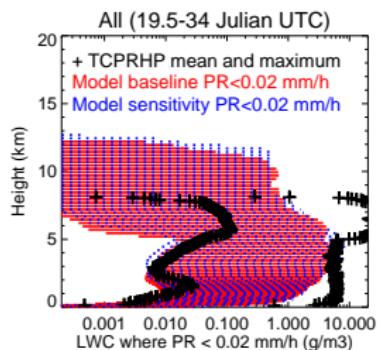
CRM Case Study Results

Radar reflectivity > 10 dBZ



Data: Peter May

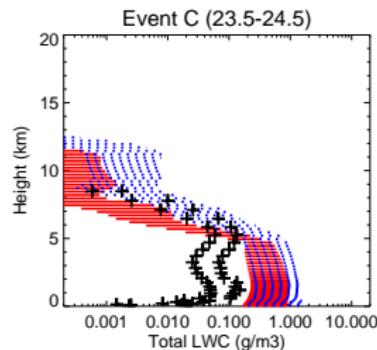
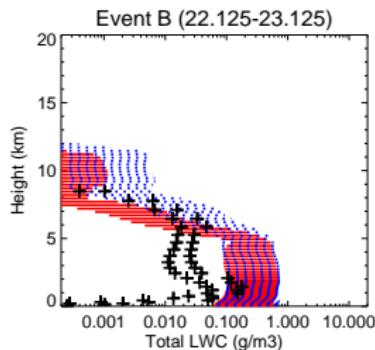
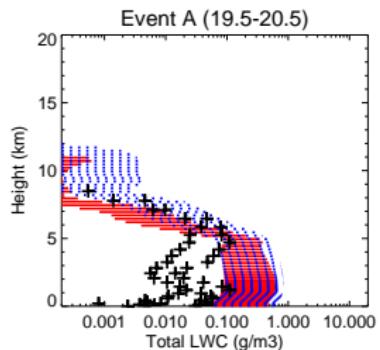
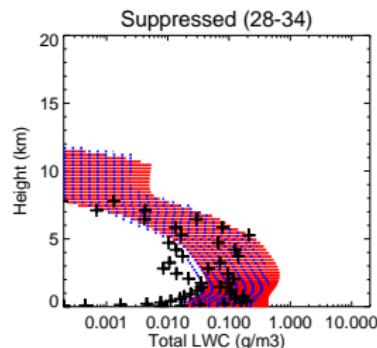
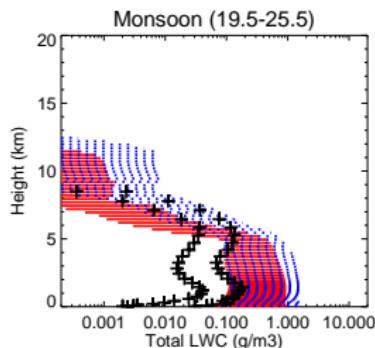
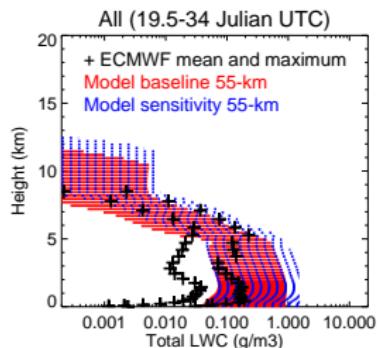
Liquid water profile



Data: Sally McFarlane/Jim Mather

CRM Case Study Results

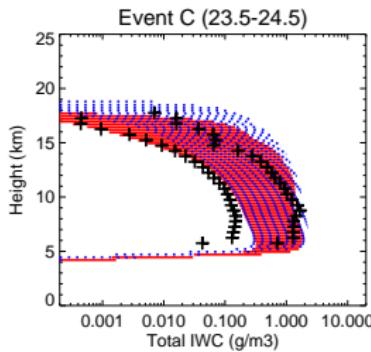
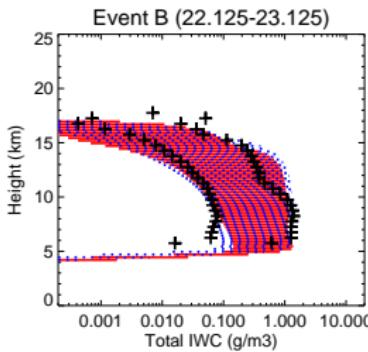
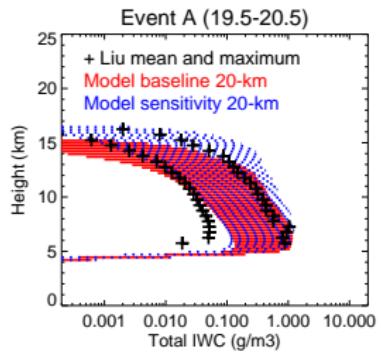
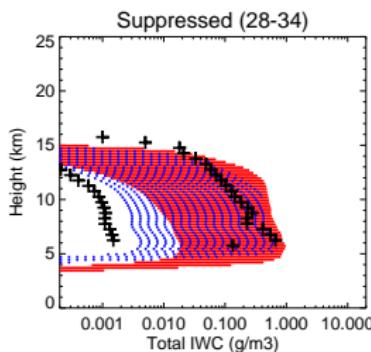
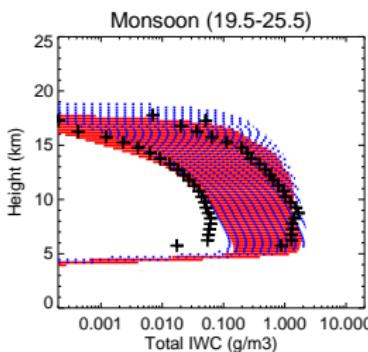
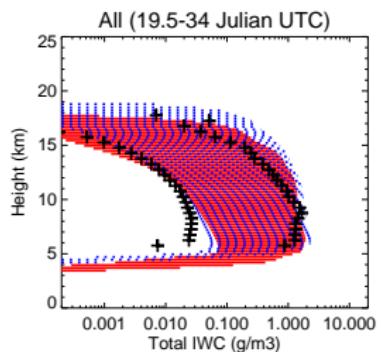
Liquid water profile



Data: *ECMWF*

CRM Case Study Results

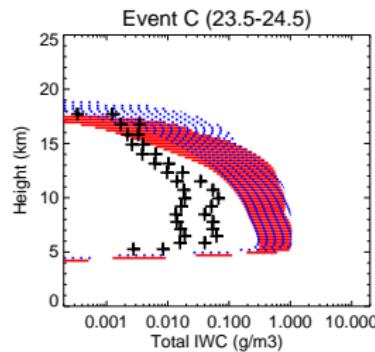
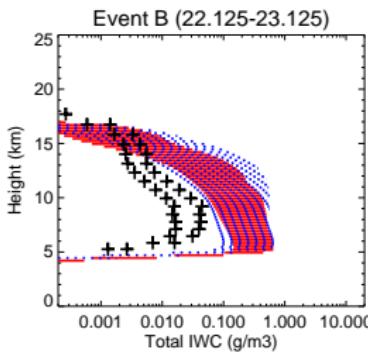
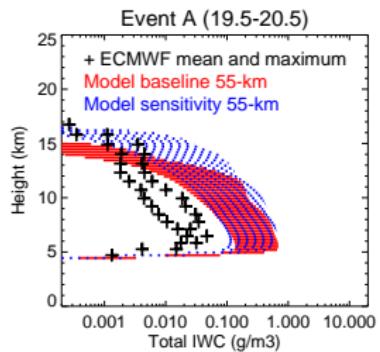
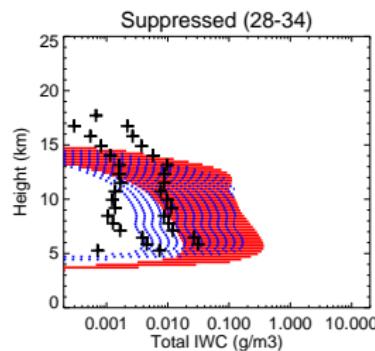
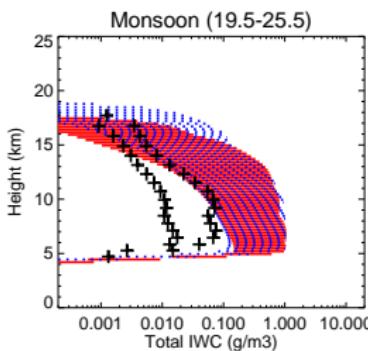
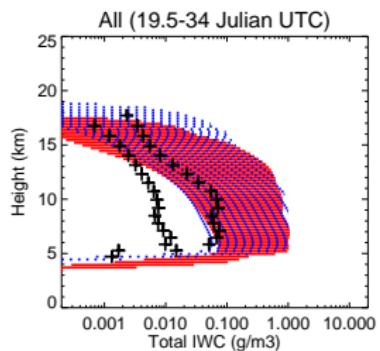
Ice water profile



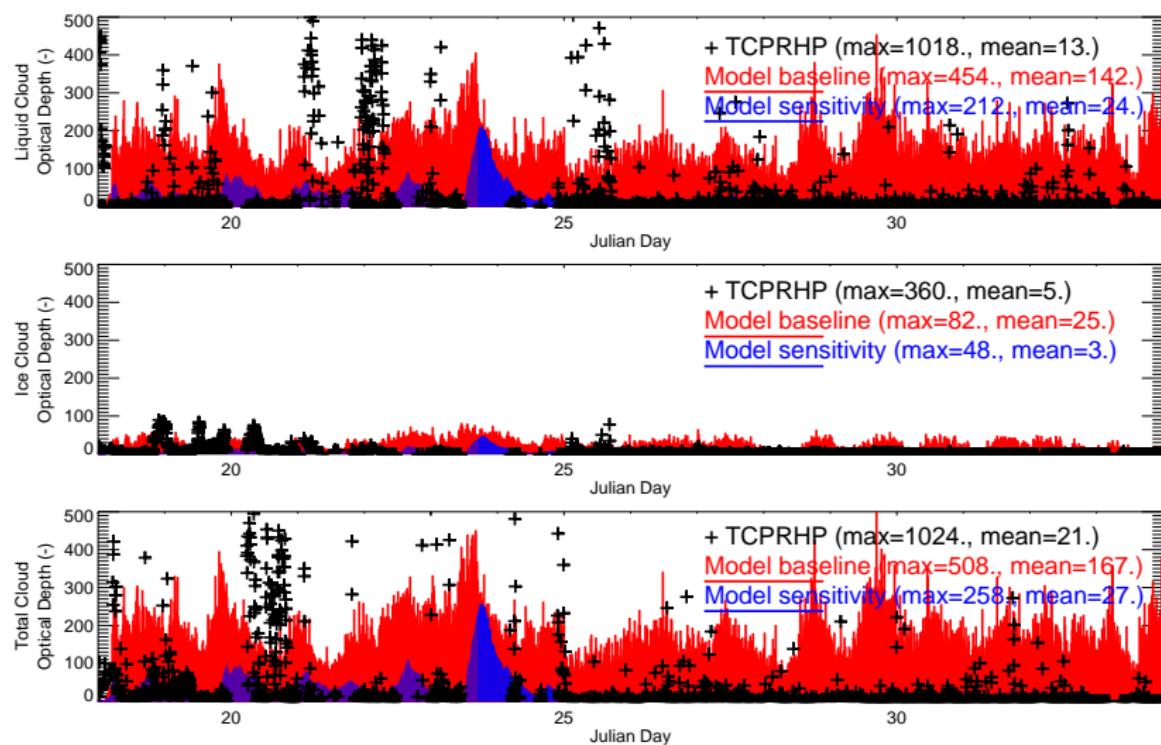
Data: Guosheng Liu

CRM Case Study Results

Ice water profile

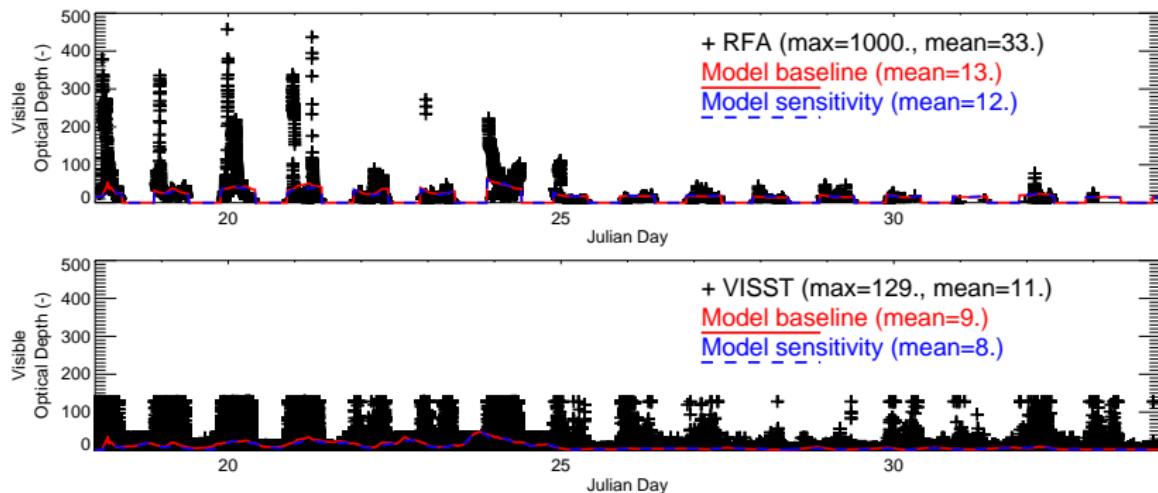
Data: *ECMWF*

Cloud optical depth



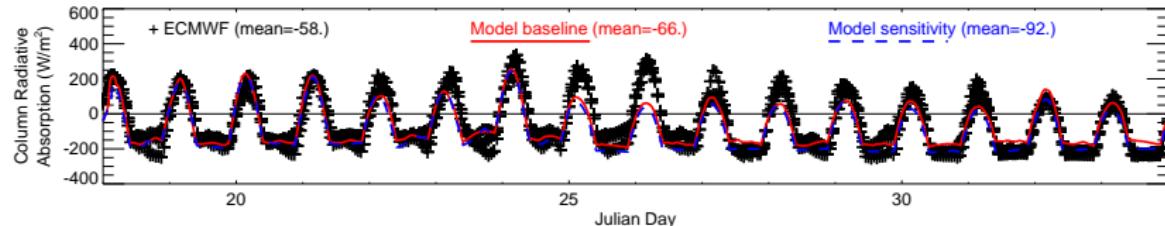
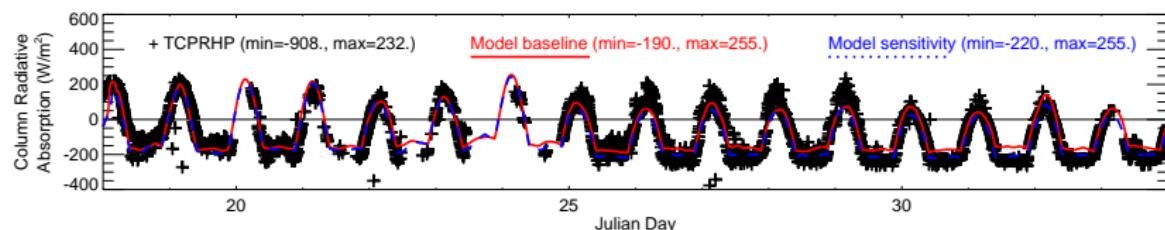
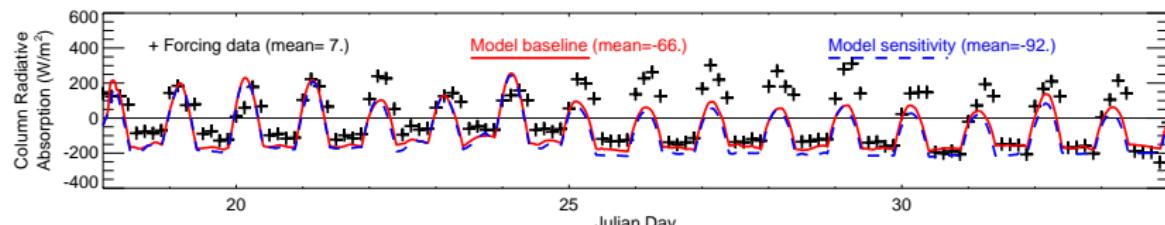
Data: *Sally McFarlane/Jim Mather*

Cloud optical depth



Data: *Chuck Long, Pat Minnis*

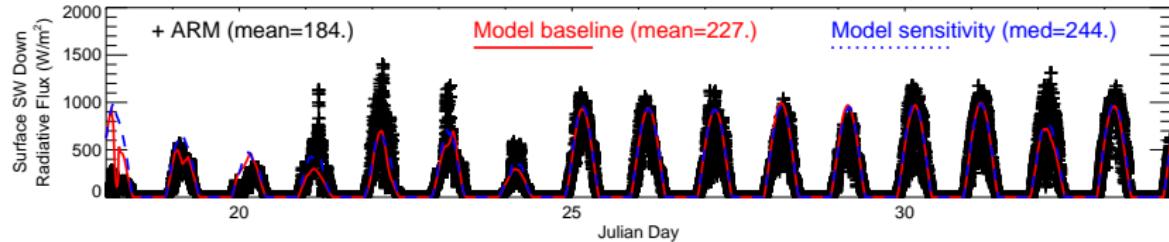
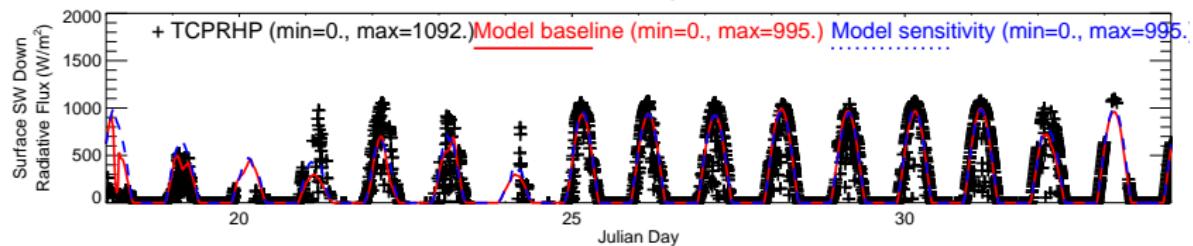
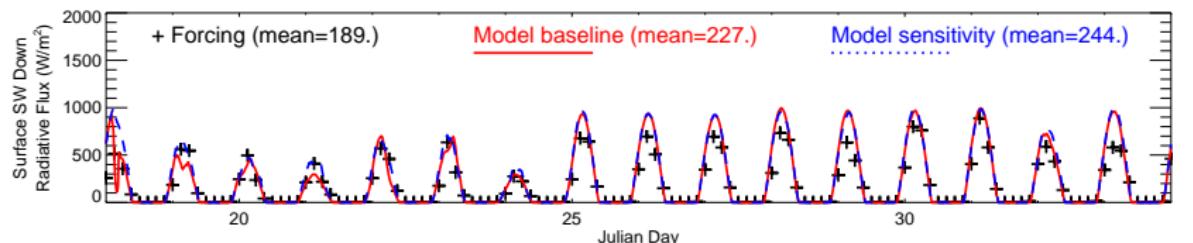
Column radiative absorption



Data: Shaocheng Xie, Sally McFarlane/Jim Mather, ECMWF

CRM Case Study Results

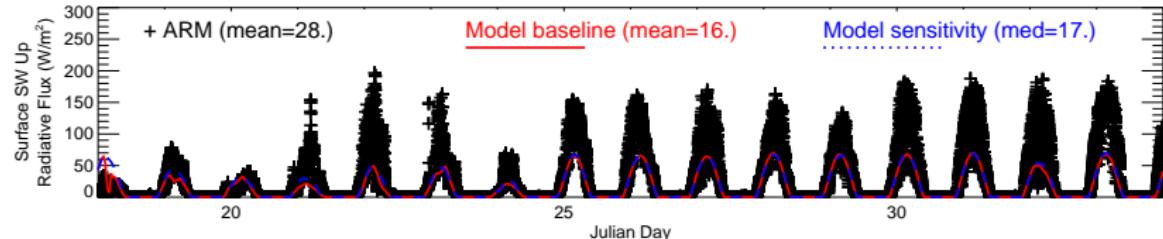
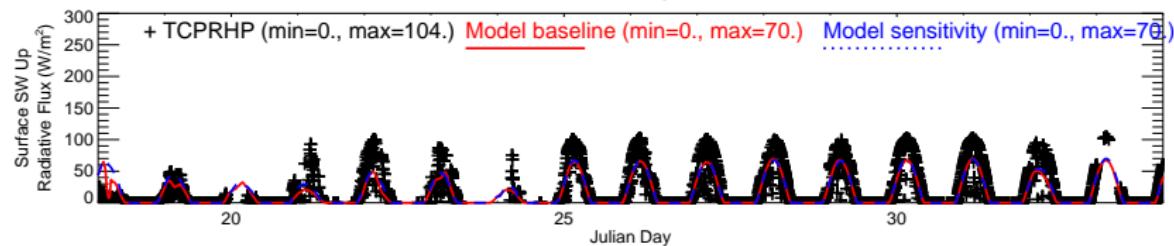
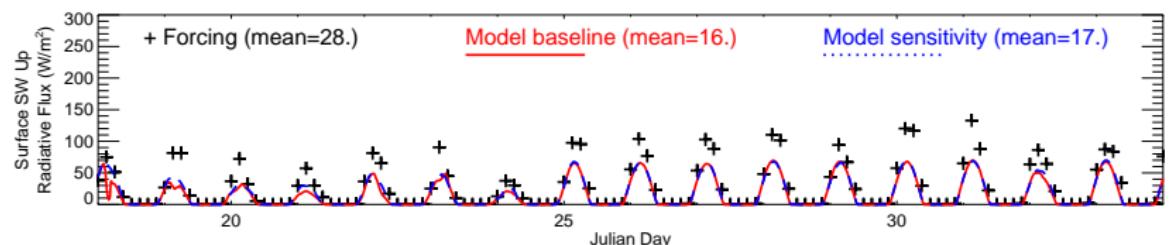
Surface broadband flux



Data: Shaocheng Xie, Sally McFarlane/Jim Mather, Chuck Long

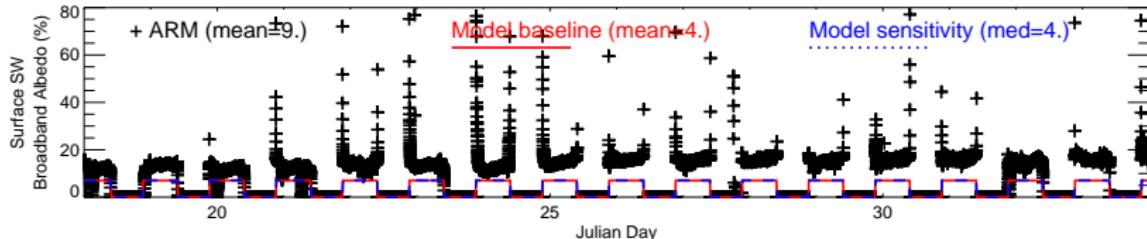
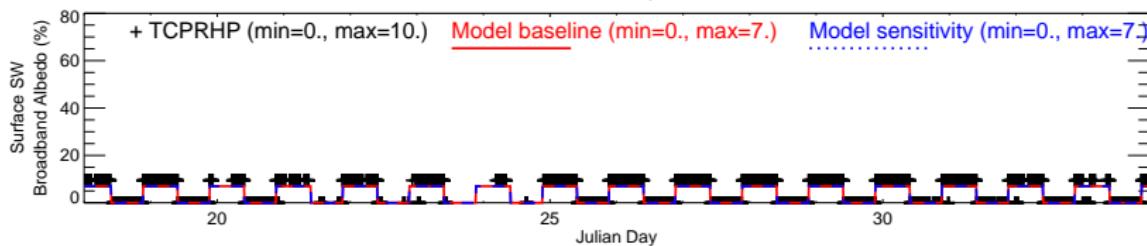
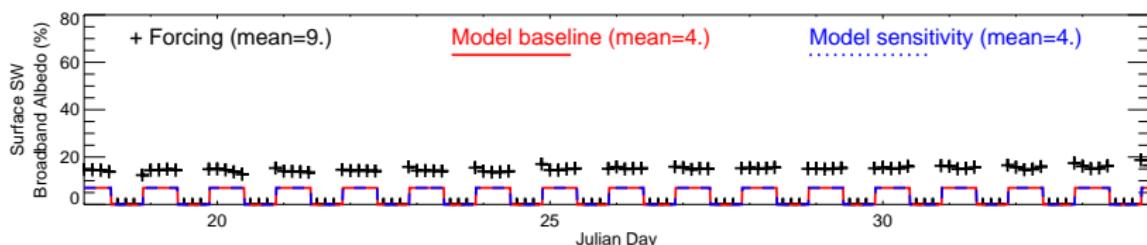
CRM Case Study Results

Surface broadband flux



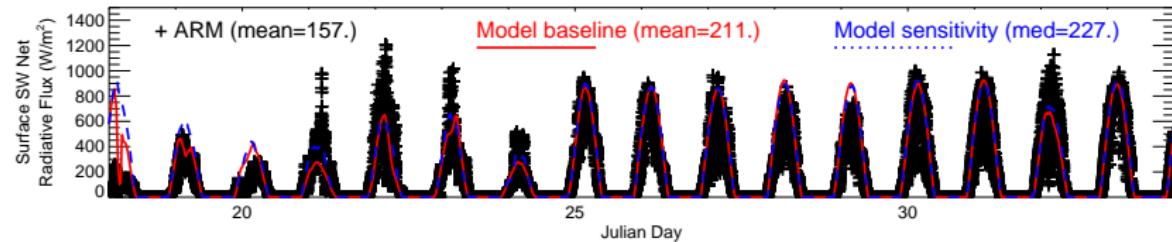
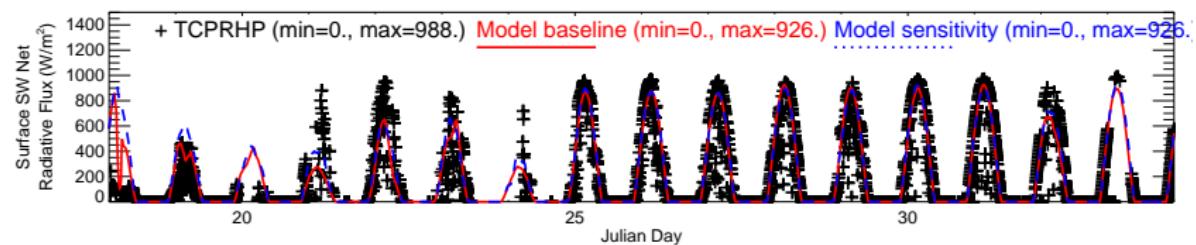
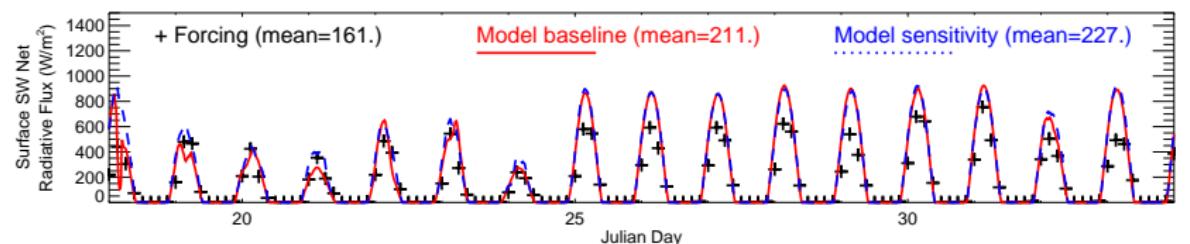
Data: Shaocheng Xie, Sally McFarlane/Jim Mather, Chuck Long

Surface broadband flux



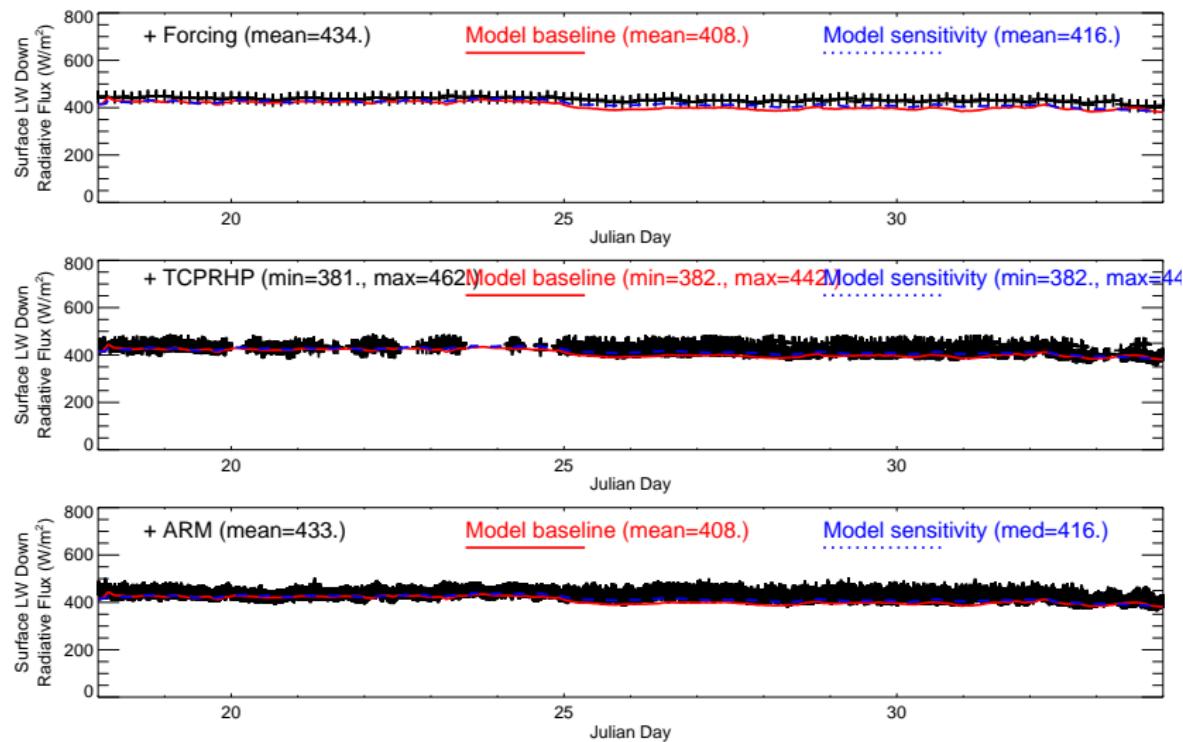
Data: Shaocheng Xie, Sally McFarlane/Jim Mather, Chuck Long

Surface broadband flux



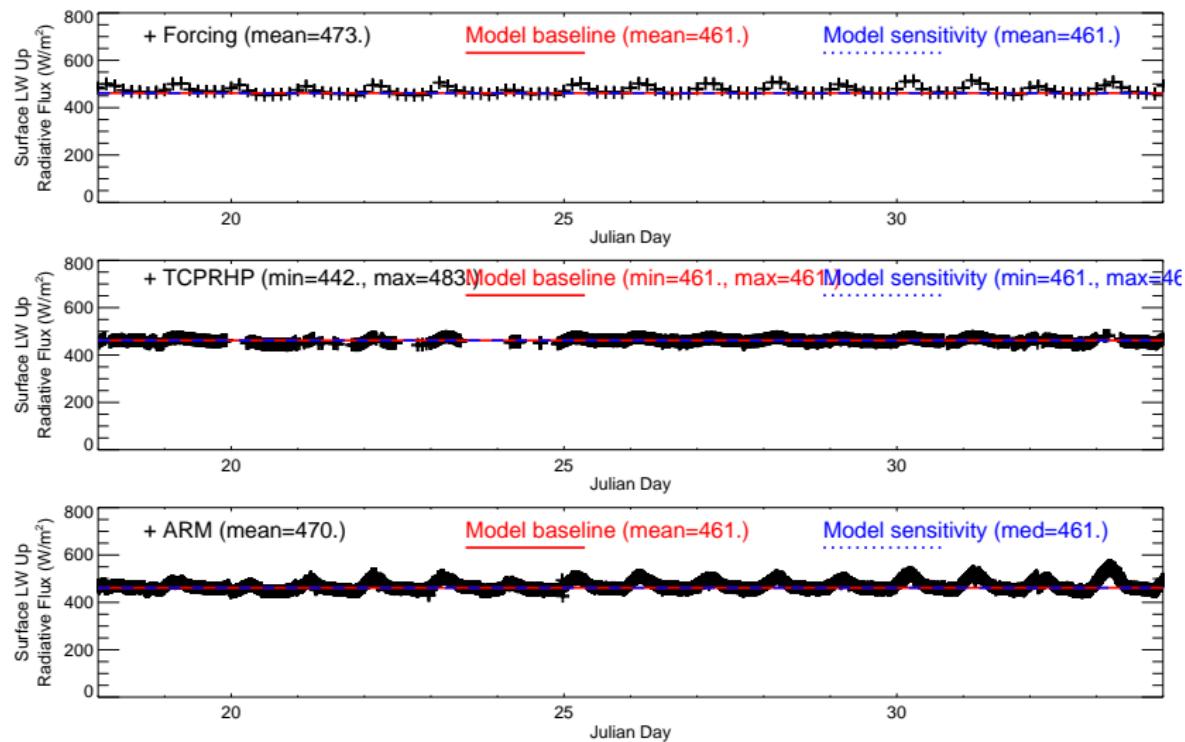
Data: Shaocheng Xie, Sally McFarlane/Jim Mather, Chuck Long

Surface broadband flux



Data: Shaocheng Xie, Sally McFarlane/Jim Mather, Chuck Long

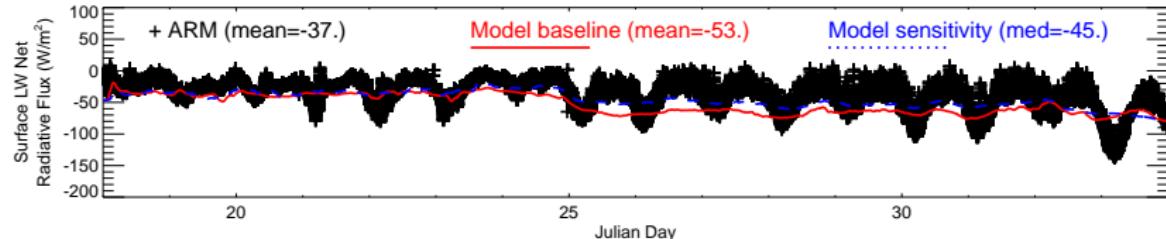
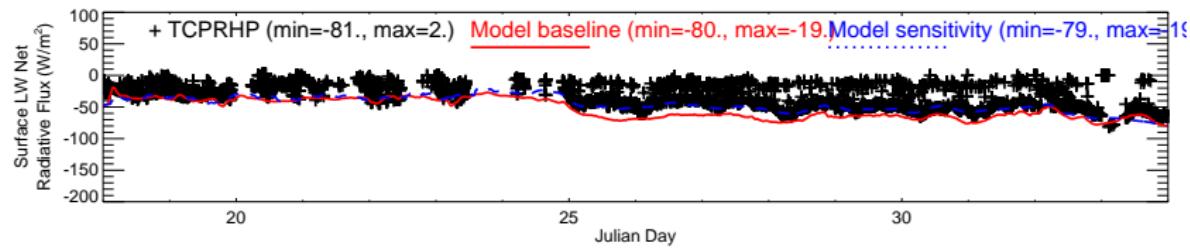
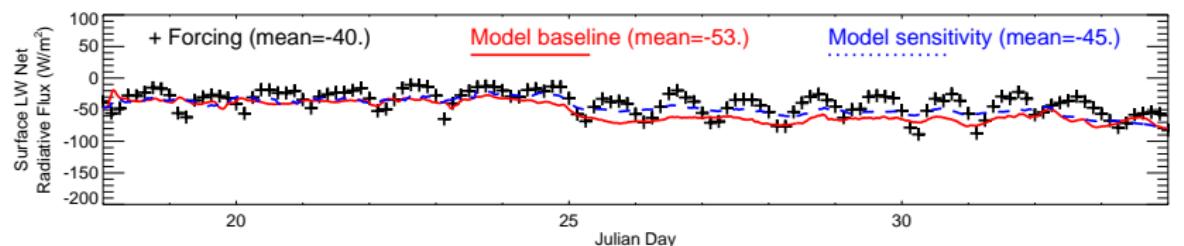
Surface broadband flux



Data: Shaocheng Xie, Sally McFarlane/Jim Mather, Chuck Long

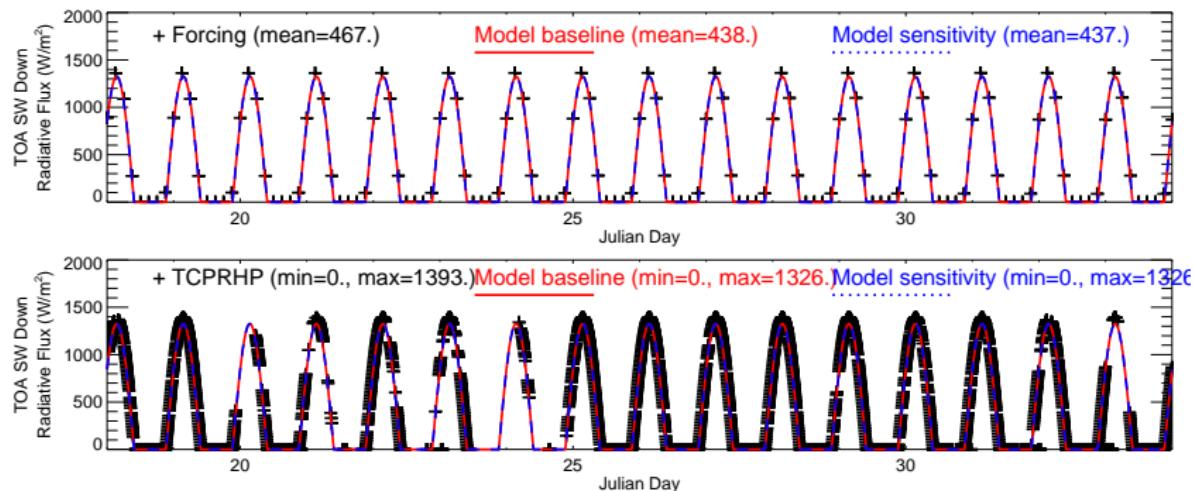
CRM Case Study Results

Surface broadband flux



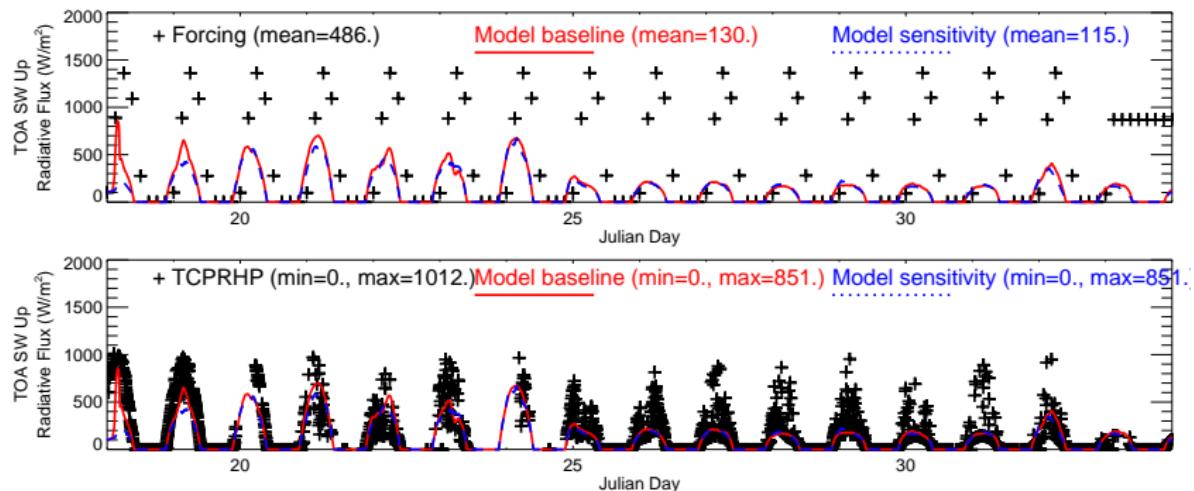
Data: Shaocheng Xie, Sally McFarlane/Jim Mather, Chuck Long

Top-of-atmosphere broadband flux



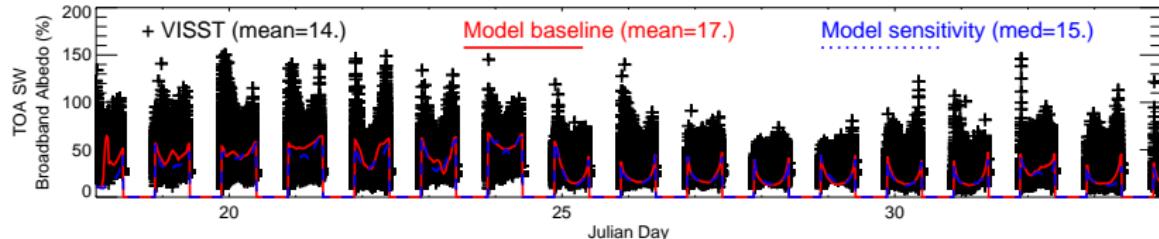
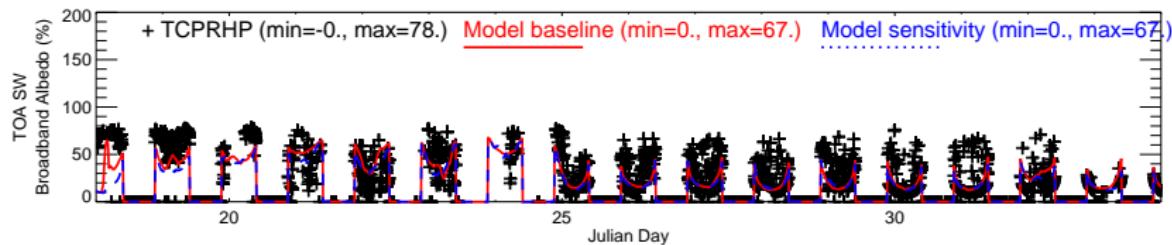
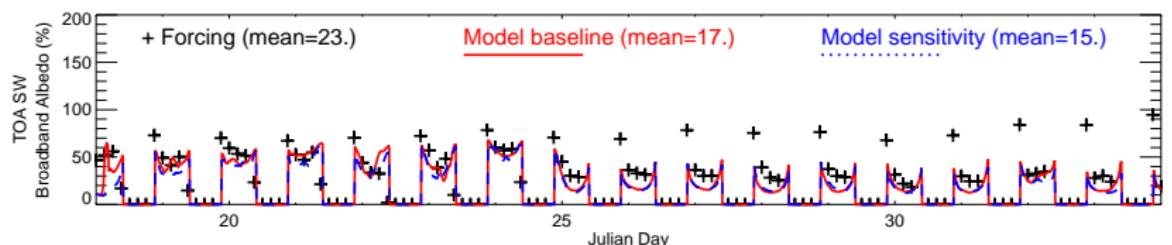
Data: *Shaocheng Xie, Sally McFarlane/Jim Mather*

Top-of-atmosphere broadband flux



Data: *Shaocheng Xie, Sally McFarlane/Jim Mather*

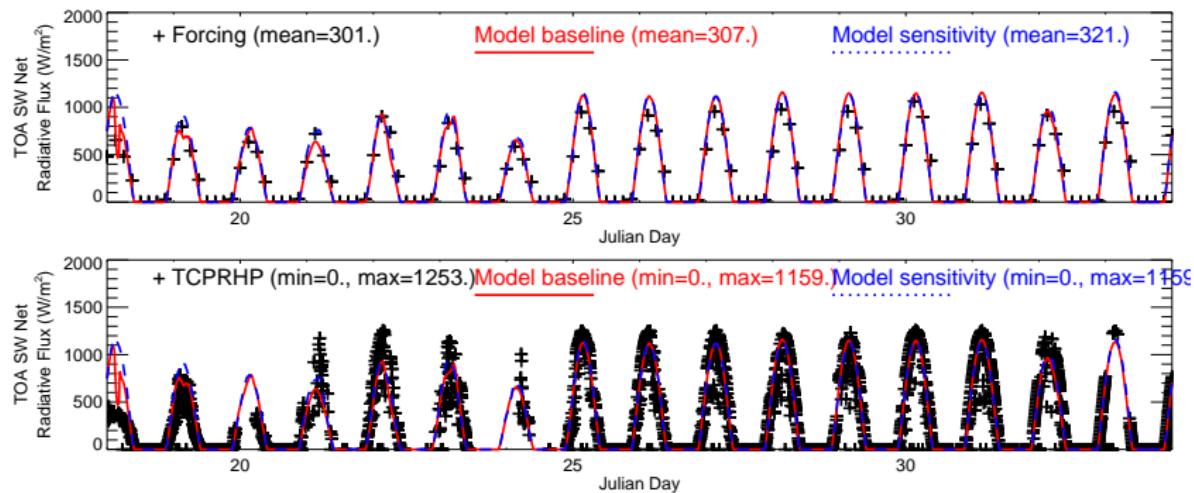
Top-of-atmosphere broadband flux



Data: Shaocheng Xie, Sally McFarlane/Jim Mather, Pat Minnis

CRM Case Study Results

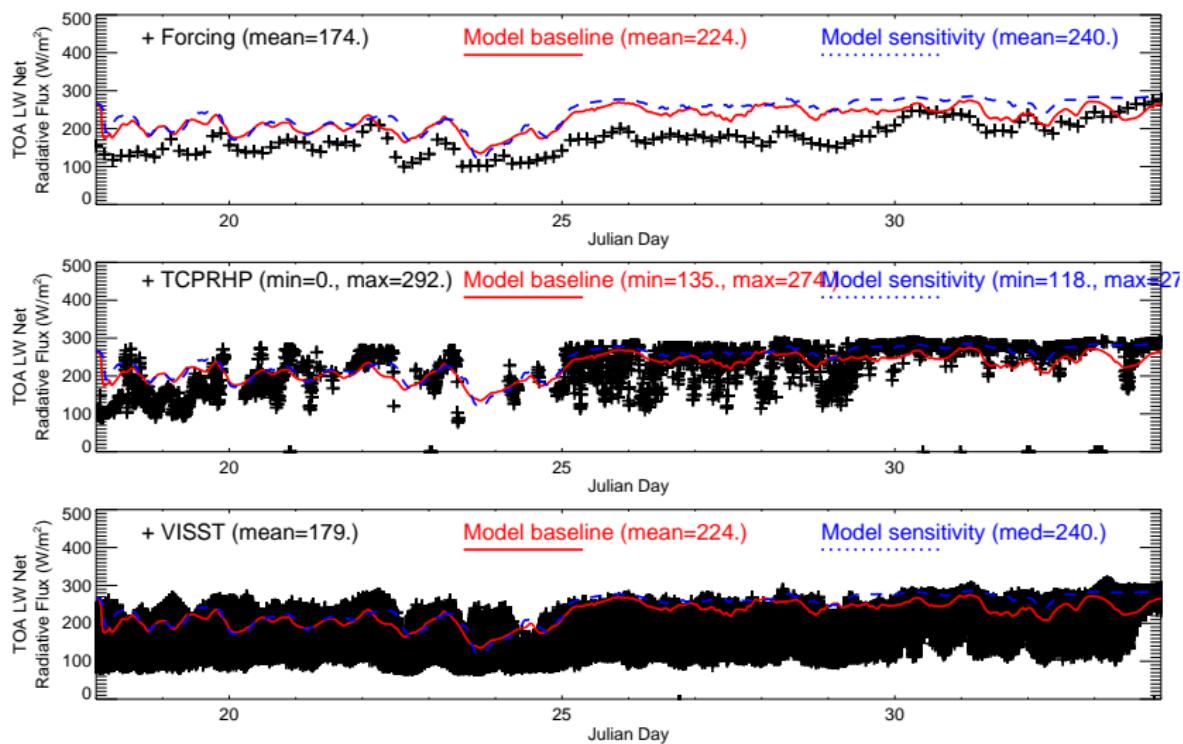
Top-of-atmosphere broadband flux



Data: *Shaocheng Xie, Sally McFarlane/Jim Mather*

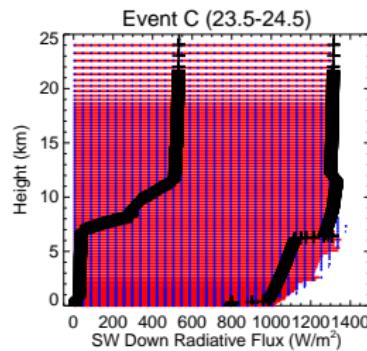
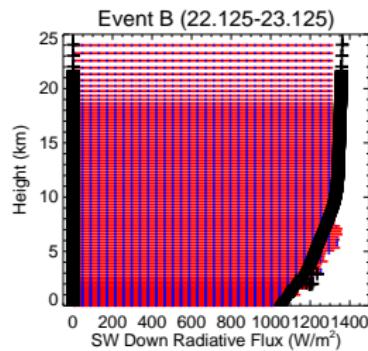
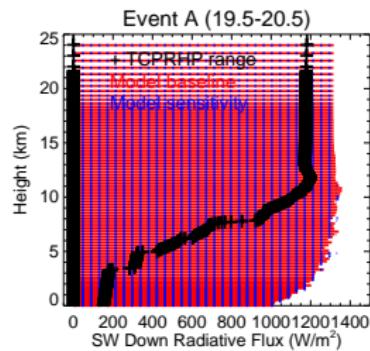
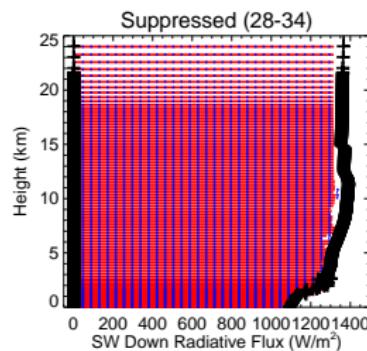
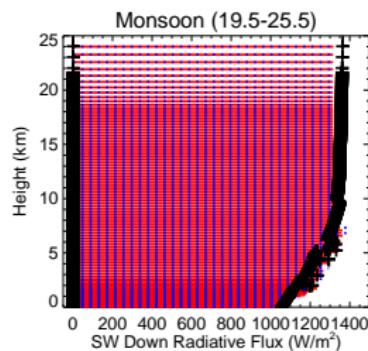
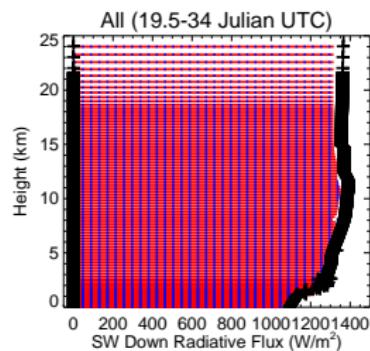
CRM Case Study Results

Top-of-atmosphere broadband flux



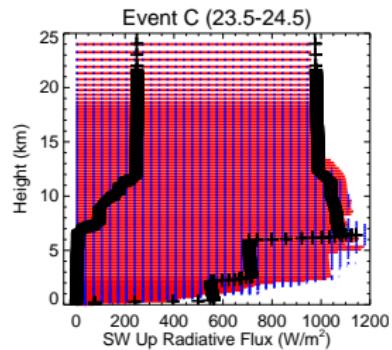
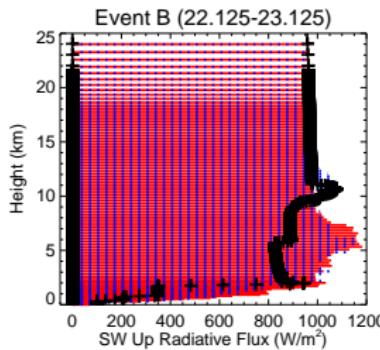
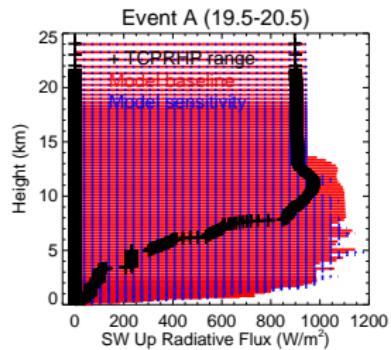
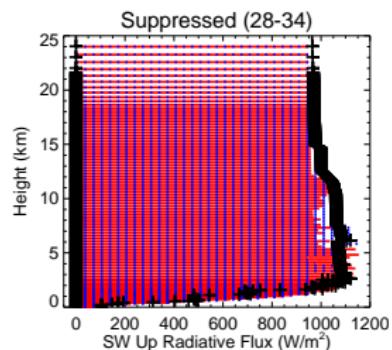
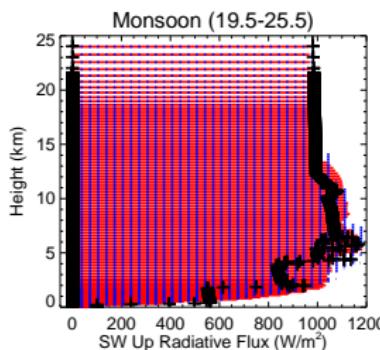
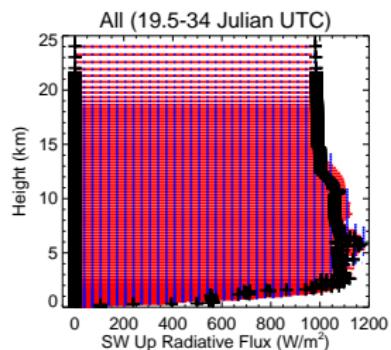
Data: Shaocheng Xie, Sally McFarlane/Jim Mather, Pat Minnis

Broadband flux profile



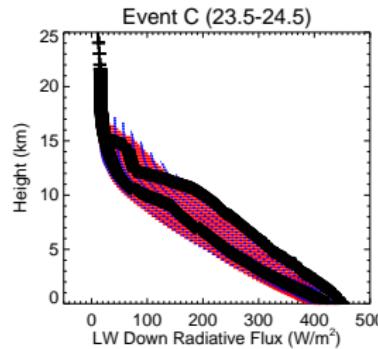
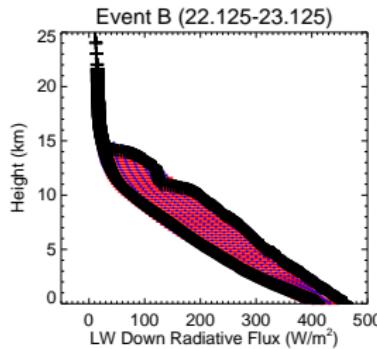
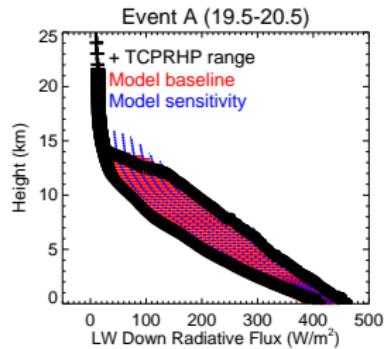
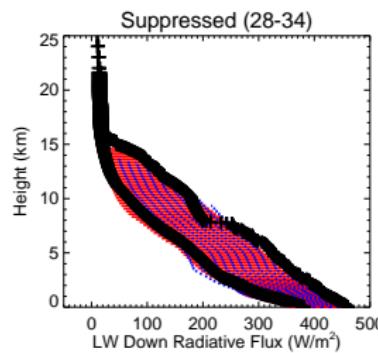
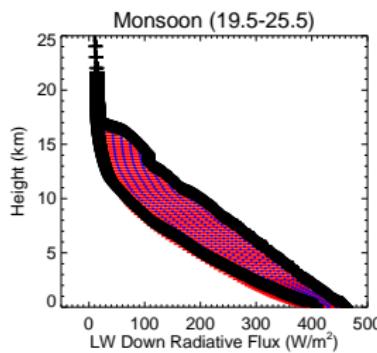
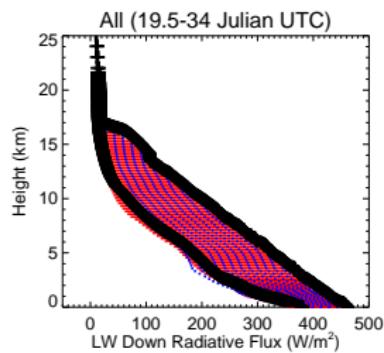
Data: Sally McFarlane/Jim Mather

Broadband flux profile



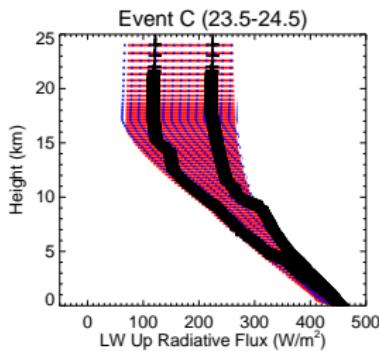
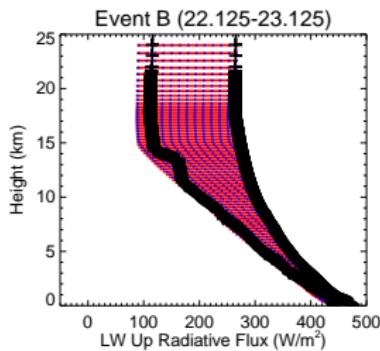
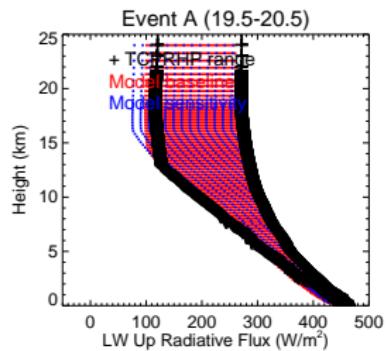
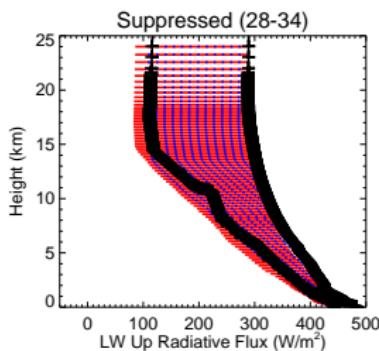
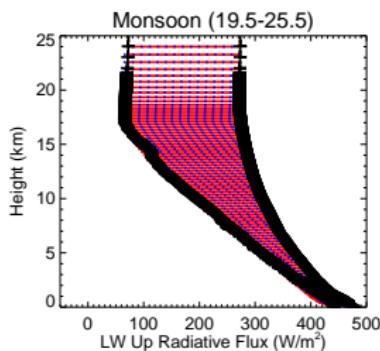
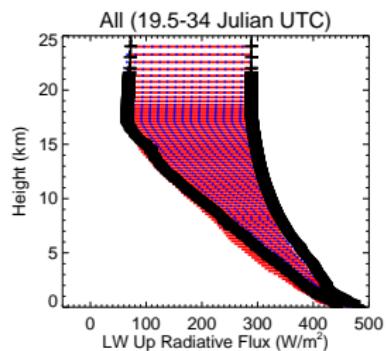
Data: Sally McFarlane/Jim Mather

Broadband flux profile



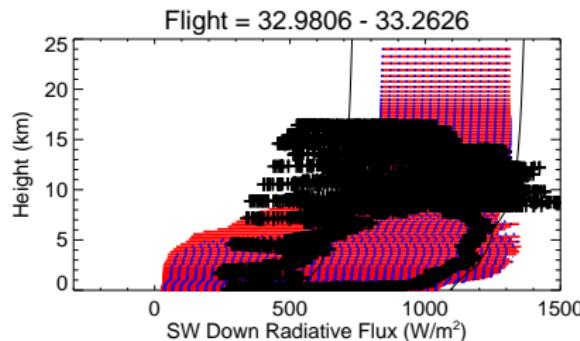
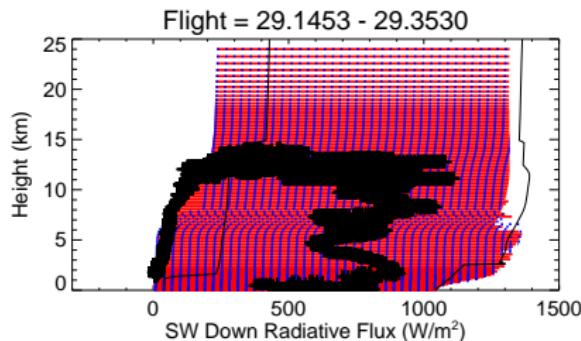
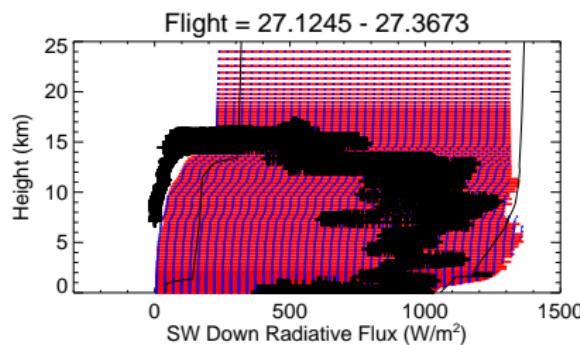
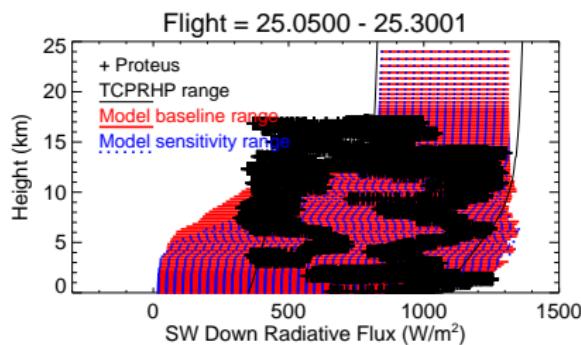
Data: Sally McFarlane/Jim Mather

Broadband flux profile



Data: Sally McFarlane/Jim Mather

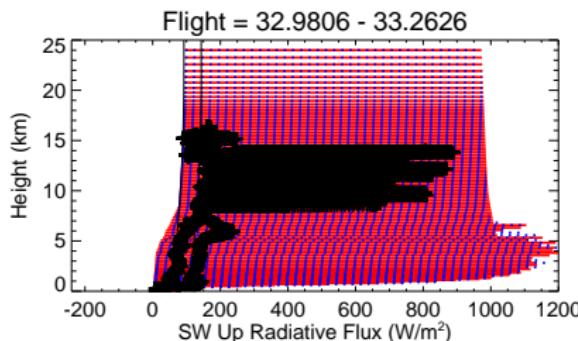
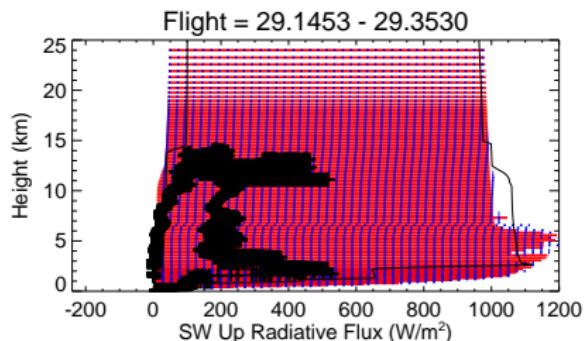
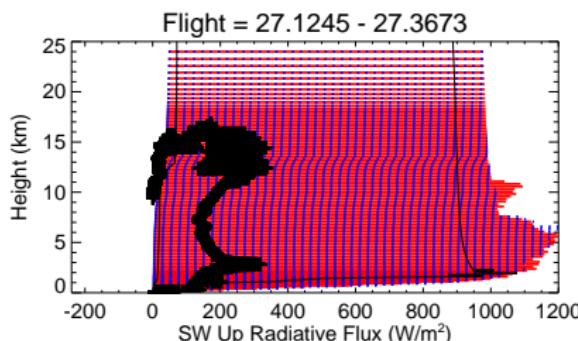
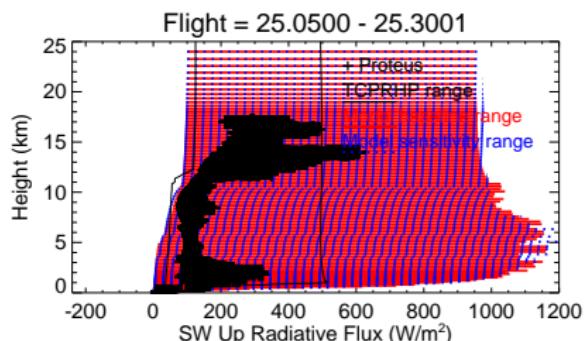
In situ data



Data: Tim Tooman/Bob McCoy, Sally McFarlane/Jim Mather

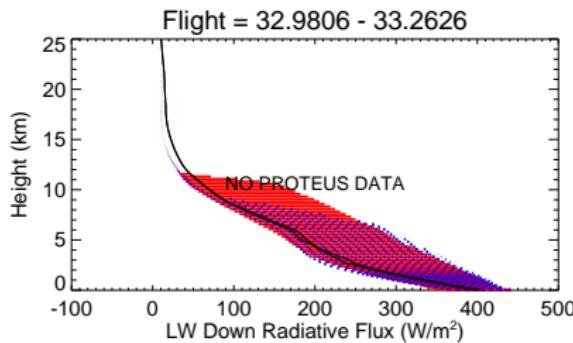
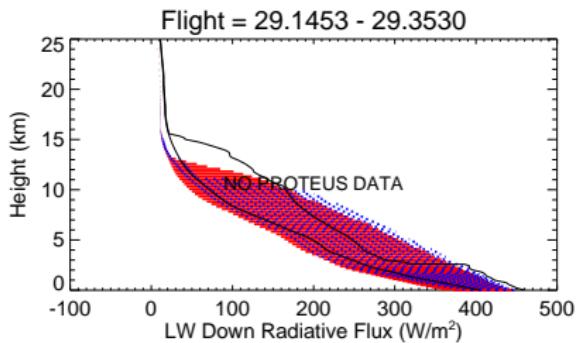
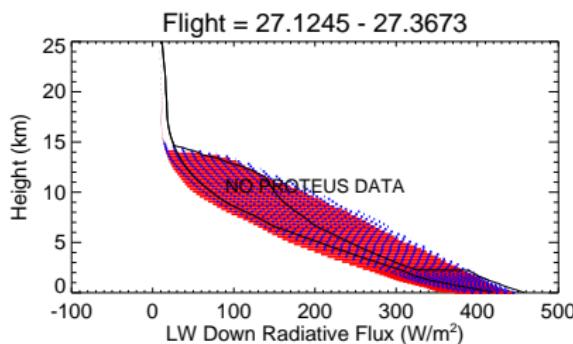
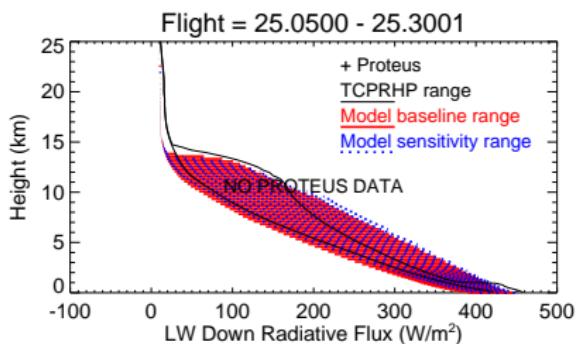
CRM Case Study Results

In situ data

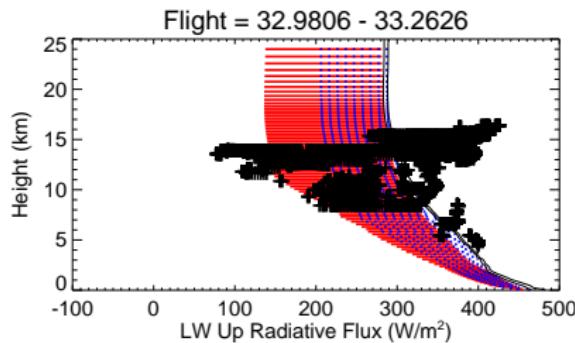
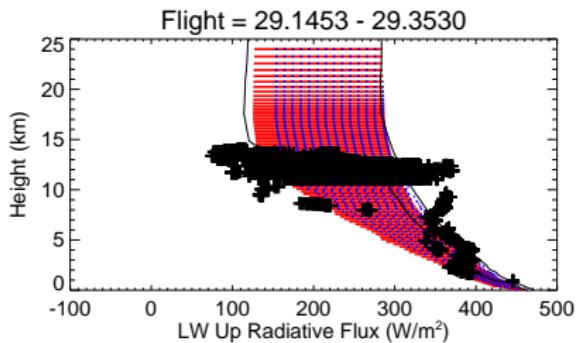
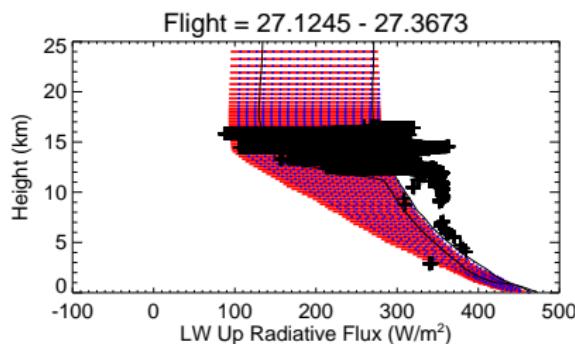
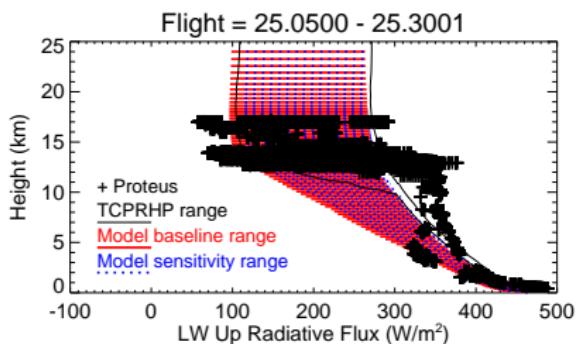


Data: Tim Tooman/Bob McCoy, Sally McFarlane/Jim Mather

In situ data

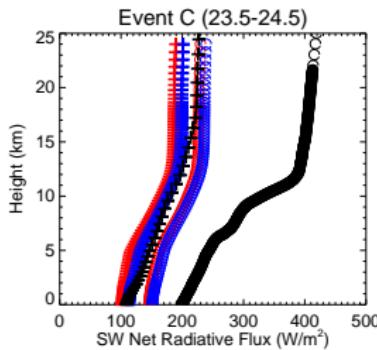
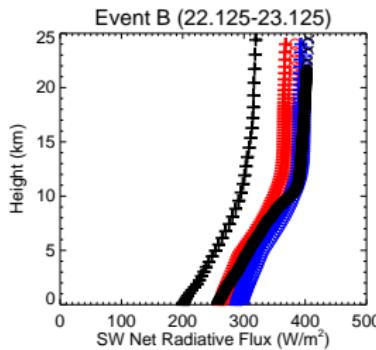
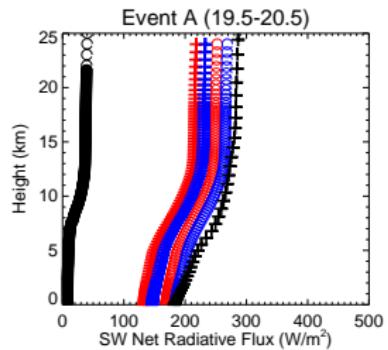
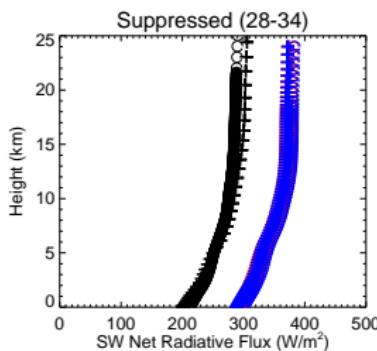
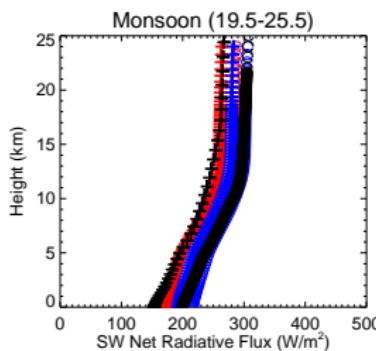
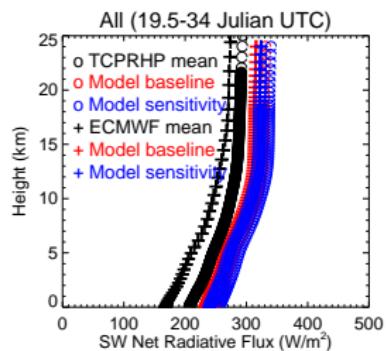


In situ data



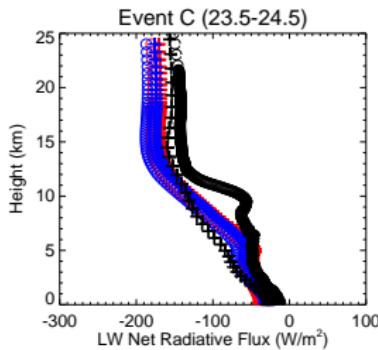
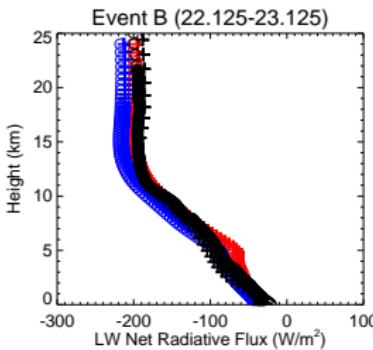
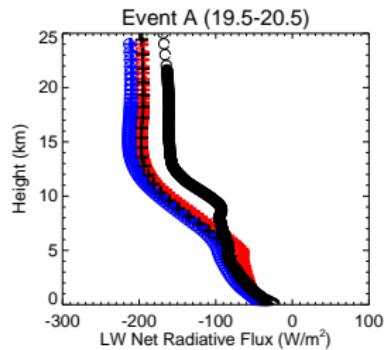
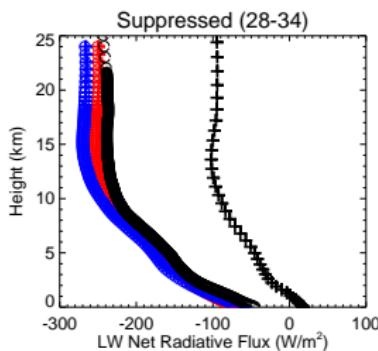
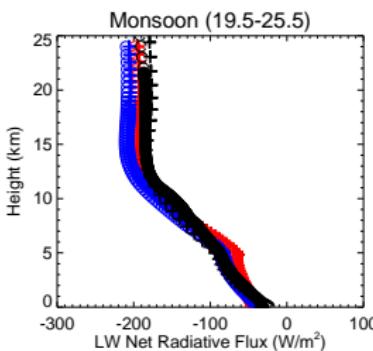
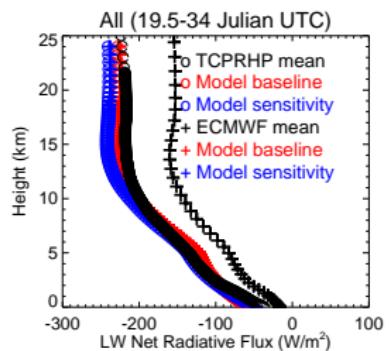
CRM Case Study Results

Net broadband flux profile



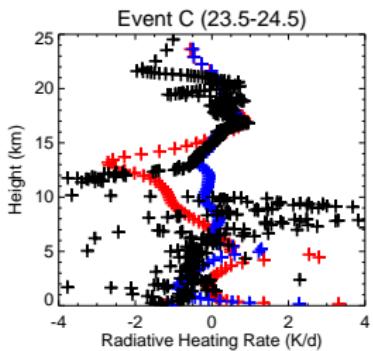
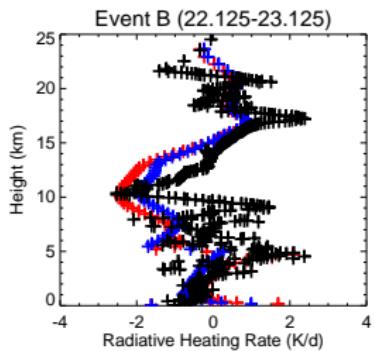
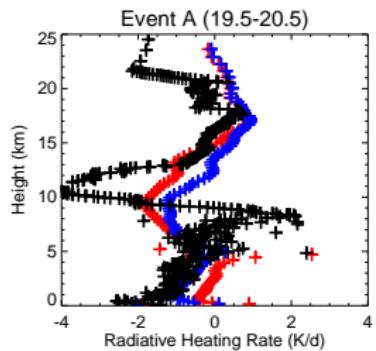
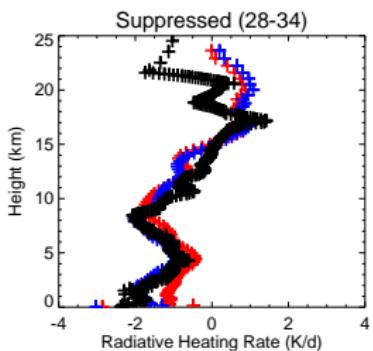
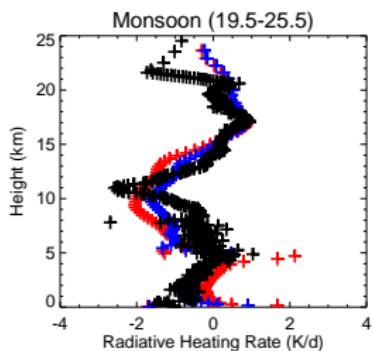
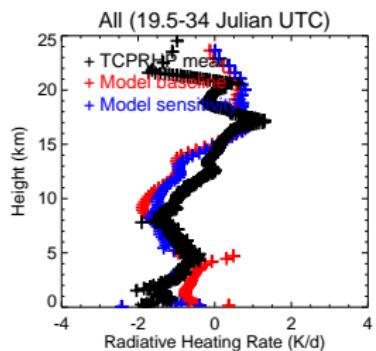
Data: Sally McFarlane/Jim Mather, ECMWF

Net broadband flux profile



Data: Sally McFarlane/Jim Mather, ECMWF

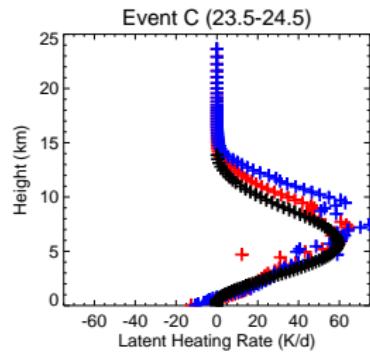
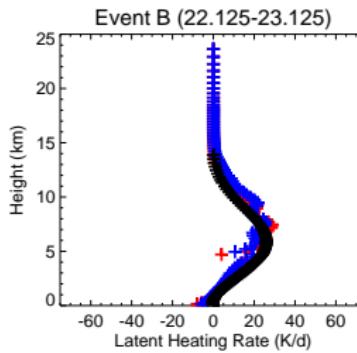
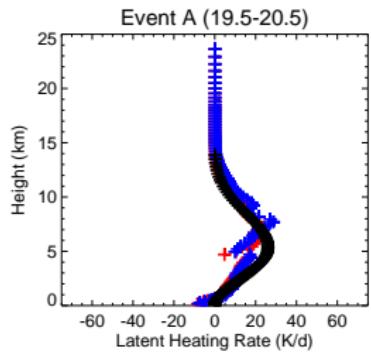
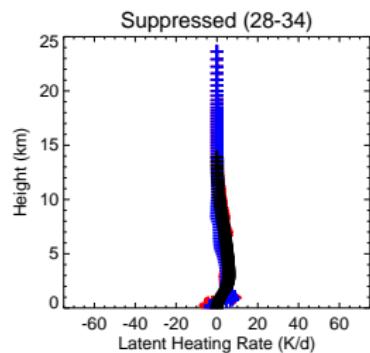
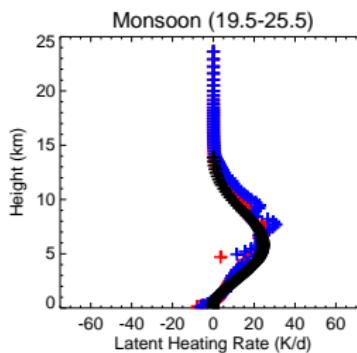
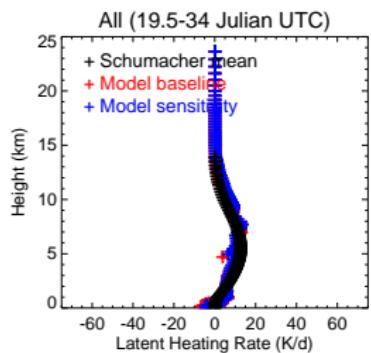
Radiative heating profile



Data: Sally McFarlane/Jim Mather

CRM Case Study Results

Latent heating profile



Data: *Courtney Schumacher*

Summary

- first goal: model evaluation
 - did we miss any useful diagnostics?
 - <http://science.arm.gov/wg/cpm/scm/scmic6> (table 1)
 - direct versus diffuse?
 - spectral?
 - do you have any comments?
 - <http://www.giss.nasa.gov/~fridlind/twp-ice/data> (images)
 - positive or negative
 - requested diagnostics can still be changed
- second goal: convective transport (water vapor)